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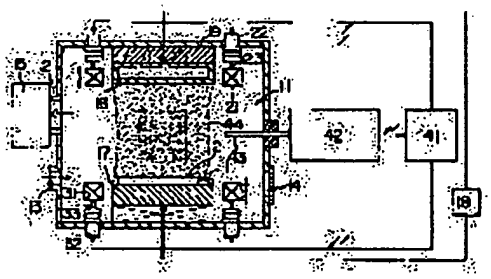
(54) SPUTTERING SYSTEM

(57)Abstract:

PURPOSE: To obtain a sputtering system in which stability and uniformity are enhanced in plasma discharge by moving each magnet unit and each electrode relatively through a driver being controlled depending on the measurement results of a plasma monitor.

CONSTITUTION: DC voltage or high frequency voltage is applied from a power supply unit 18 to upper and lower electrodes 16, 17 in a processing chamber 11 of a sputtering system. The upper electrode 16 is cooled while a wafer 1 is mounted on a disc type lower electrode 17. A ring type permanent magnet 21 is arranged around the upper electrode 16 and moved up and down by means of an upper vertical driver 22. Similarly, a ring type permanent magnet 31 is supported vertically upward on the outside of the lower electrode 17 and they are regulated by controlling vertical driving thereof through a controller 41. The controller 41 monitors discharging state of a probe 43 and distribution thereof thus regulating the permanent magnets 21, 31 to optimal positions.



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* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] The processing room in which a processed material is held, and the electrode of the pair in which this processing interior of a room is furnished, and the plasma is made to form, In a sputtering system equipped with each magnet system which forms the field which is allotted to the surroundings of two electrodes, respectively and shuts up an electron near the two electrodes While being constituted so that said each magnet system and each electrode may be relatively moved by the driving gear While being constituted that this driving gear has so that [a drive] it may be controlled by the controller and furnishing the plasma monitoring apparatus which measures the plasma formed of said two electrodes It is the sputtering system which this plasma monitoring apparatus is connected to said controller, and is characterized by constituting the controller so that said driving gear may be controlled according to the measurement result of a plasma monitoring apparatus.
[Claim 2] Said driving gear is a sputtering system according to claim 1 characterized by being constituted so that said each magnet system and relative displacement of each electrode may become the axial center and parallel direction of two electrodes.
[Claim 3] Said driving gear is a sputtering system according to claim 1 characterized by being constituted so that said each magnet system may be moved in the direction of a path of each electrode.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention is used for the sputtering technique of performing etching processing to the metal membrane formed on the semi-conductor wafer (henceforth a wafer), an insulator layer, etc. in the production process of a semiconductor device, concerning a sputtering technique and the etching processing technique in which sputtering was used especially, and relates to an effective thing.
[0002]
[Description of the Prior Art] In the production process of a semiconductor device, a sputter etching art may be used for performing etching processing to the metal membrane formed on the wafer, an insulator layer, etc. The sputtering system, ****** which are constituted so that it may have the electrode of the pair which high-frequency voltage is impressed and forms the plasma as a sputtering system which enforces this sputter etching art, and the permanent magnet arranged on the circumference of two electrodes, respectively and an electron may be shut up near each electrode surface by the field of both permanent magnets.
[0003] In addition, as an example which has expressed the sputter etching technique, they are Denki Shoin Issue "Basic of plasma processing" November 19, Showa 60 issue, P225-P236, and ******.
[0004]
[Problem(s) to be Solved by the Invention] However, it sets to such a sputtering system. Since the permanent magnet with the strength of magnetism fixed as a magnet system is used, Moreover, since the distance between two electrodes and the distance between both permanent magnets are being fixed, [that the processing interior of a room is polluted, and change the electric resistance of the processing interior of a room, or the ingredient of a wafer is changed, etc. and] Even if it was the case where the plasma discharge condition between two electrodes became unstable, or plasma distribution became an ununiformity, it was shown clearly by this invention person that there was a trouble that this is not improvable.
[0005] The purpose of this invention is to offer the sputtering system which can raise the stability of the plasma discharge between two electrodes, and the homogeneity of plasma distribution.
[0006] The other purposes and the new description will become clear from description and the accompanying drawing of this specification along [said] this invention.
[0007]
[Means for Solving the Problem] It will be as follows if the outline of a typical thing is explained among invention indicated in this application.
[0008] Namely, the processing room in which a processed material is held and the electrode of the pair in which this processing interior of a room is furnished, and the plasma is made to form, In a sputtering system equipped with each magnet system which forms the field which is allotted to the surroundings of two electrodes, respectively and shuts up an electron near the two electrodes While being constituted so that said each magnet system and each electrode may be relatively moved by the driving gear While being constituted that this driving gear has so that [a drive] it may be controlled by the controller and furnishing the plasma monitoring apparatus which measures the plasma formed of said two electrodes This plasma monitoring apparatus is connected to said controller, and it is characterized by constituting the controller so that said driving gear may be controlled according to the measurement result of a plasma monitoring apparatus.
[0009]
[Function] According to the above mentioned means, since both magnet systems and two electrodes are moved relatively, as for the plasma formed of two electrodes, the discharge condition and a distribution condition will change. since [and] the relative movement of both this magnet system and two electrodes is controllable to be in the optimal condition

corresponding to the measurement result of a plasma monitoring apparatus -- the stable state of that plasma discharge condition, and the homogeneity condition of plasma part blanket-like voice -- ******** -- things are made.

[0010]

[Example] Drawing 1 is the transverse-plane sectional view showing the sputtering system which is one example of this invention. Drawing 2 (a) and (b) are each diagram for explaining the operation.

[0011] In this example, the sputtering system concerning this invention is constituted as a sputtering system which carries out sputter etching processing to the metal membrane 2 formed on the wafer 1 as a processed material.

[0012] This sputtering system 10 is equipped with the processing room 11, and the exhaust port 12 where the vacuum pumps 15, such as cryopump and an oil diffusion pump, are connected, the gas supply opening 13 with which inert gas, such as argon gas, is supplied, and the carrying-in taking-out opening 14 for taking the wafer 1 as a processed material in and out are established at the processing room 11.

[0013] Moreover, in the processing room 11, it is arranged so that the electrodes 16 and 17 of a pair may set up and down and may become parallel mutually, and between the up-and-down electrode 16 and 17, the power unit 18 for impressing direct current voltage or high-frequency voltage is connected. The electrode (henceforth a top electrode) 16 arranged on the bottom is being fixed to the head-lining side of the processing room 11 by the supporter material 19. The top electrode 16 is formed in the disk type-like hollow object, and it is constituted so that it may be cooled by the cooling section (not shown) arranged in the interior.

[0014] On the other hand, the electrode (henceforth a bottom electrode) 17 arranged on the bottom is formed in the shape of a disk type, and it is constituted so that the wafer 1 as a processed material may be laid and it can hold.

[0015] The top permanent magnet 21 as one magnet system is arranged on the outside of the top electrode 16, and this permanent magnet 21 is formed in the circular ring configuration as a whole so that the top electrode 16 may be surrounded. And the rectilinear-motion driving gear (henceforth top vertical-drive equipment) 22 which changes from cylinder equipment etc. to the head-lining side of the processing room 11 is arranged on the outside of the top electrode 16, and is furnished downward [perpendicular direction]. The lifting and holding of the top permanent magnet 21 are carried out to the lower limit of the push rod 23 of besides side vertical-drive equipment 22 fixed. Therefore, the top permanent magnet 21 is moved in the vertical direction by top vertical-drive equipment 22.

[0016] On the other hand, the bottom permanent magnet 31 as a magnet system of another side is arranged on the outside of the bottom electrode 17, and this permanent magnet 31 is formed in the circular ring configuration as a whole so that the bottom electrode 17 may be surrounded. And the rectilinear-motion driving gear (henceforth bottom vertical-drive equipment) 32 which changes from cylinder equipment etc. to the base of the processing room 11 is arranged on the outside of the bottom electrode 17, and is furnished to perpendicular direction facing up. The bottom permanent magnet 31 is supported by the upper limit of the push rod 33 of this bottom vertical-drive equipment 32 fixed. Therefore, the bottom permanent magnet 31 is moved in the vertical direction by bottom vertical-drive equipment 32.

[0017] Top vertical-drive equipment 22 and bottom vertical-drive equipment 32 are connected to the outgoing end of a controller 41, and this controller 41 is constituted so that the drive of both vertical-drive equipments 22 and 32 may be controlled. Therefore, modification adjustment of the top permanent magnet 21 and the bottom permanent magnet 31 is carried out by assignment of a controller 41, respectively in each location to the top electrode 16 and the bottom electrode 17.

[0018] The plasma monitoring apparatus 42 is connected to the input edge of a controller 41. The plasma monitoring apparatus 42 is equipped with the probe needle 43, and the probe needle 43 is inserted free [an attitude] into the processing room 12. By measuring electron temperature, an electronic consistency, an electronic plasma electrical potential difference in each location of the direction of a path in the processing room 11, etc. with the probe needle 43, this plasma monitoring apparatus 42 is constituted so that monitoring of the discharge condition and distribution condition of the plasma can be carried out.

[0019] And corresponding to the distribution condition of the plasma 44 measured by this plasma monitoring apparatus 42, by controlling the drive of top vertical-drive equipment 22 and bottom vertical-drive equipment 32, respectively, the controller 41 is constituted so that modification adjustment of the top permanent magnet 21 and the bottom permanent magnet 31 can be carried out in the optimal location, respectively.

[0020] Next, one example of the sputter etching approach by the sputtering system concerning said configuration is explained.

[0021] First, while the wafer 1 which should be processed is carried in from the carrying-in taking-out opening 14 by the suitable handler (not shown) into the processing room 11, it is transferred on the bottom electrode 17 and held.

[0022] Then, if the processing room 11 is exhausted by the high vacuum (for example, 10^{-7} Torr) by the exhaust port 12, the argon gas as sputtering gas will be supplied to the processing room 11 from the gas supply opening 13. By this gas

supply, the pressure in the processing room 11 becomes for example, 10-3Torr extent.
[0023] Then, direct current voltage or high-frequency voltage is impressed by the power unit 18 between two electrodes 16 and 17. Of the electrical-potential-difference impression between two electrodes 16 and 17, the plasma 44 is formed between two electrodes 16 and 17 as shown in drawing 1 .
[0024] Sputtering of the metal membrane 2 which the argon was excited by the plasma 44 and put on the wafer 1 with the argon is carried out. Consequently, etching processing of the metal membrane 2 on a wafer 1 will be carried out. At this time, the electron of the plasma 44 is shut up near the up-and-down electrodes 16 and 17 with the up-and-down permanent magnets 21 and 31.
[0025] After desired etching processing is completed by the above actuation, the wafer [finishing / processing] 1 is taken up from the bottom electrode 17, and is taken out out of the processing room 11 by the handler from the carrying-in taking-out opening 14. Then, the following wafer 1 is supplied on the bottom electrode 17 by the handler.
[0026] Henceforth, by repeating said actuation, sequential operation is carried out and the etching processing by sputtering goes to each wafer 1.
[0027] By the way, although the discharge condition and distribution condition of the plasma 44 are influenced by the field which the up-and-down permanent magnets 21 and 31 form, when the permanent magnets 21 and 31 of the upper and lower sides allotted to the surroundings of the up-and-down electrodes 16 and 17, respectively are being fixed, the effect the discharge condition and distribution condition of the plasma 44 are influenced by the up-and-down permanent magnets 21 and 31 always becomes fixed. Therefore, when the up-and-down electrodes 16 and 17 are being fixed, it sets. [that the inside of the processing room 11 is polluted, and change the electric resistance in the processing room 11, or the ingredient of a wafer 1 is changed, etc. and] This can be improved even if it is the case where two electrodes 16 and the discharge condition of the plasma 44 between 17 became unstable, or plasma distribution becomes an ununiformity.
[0028] However, in this example, since it is constituted so that the up-and-down permanent magnets 21 and 31 may be moved in the vertical direction by the up-and-down vertical-drive equipments 22 and 32, respectively, modification adjustment of the field which the permanent magnets 21 and 31 of the upper and lower sides exerted on the discharge condition and distribution condition of the plasma 44 form can be carried out. That is, modification adjustment of the discharge condition and distribution condition of the plasma 44 can be carried out by carrying out modification adjustment of the location of the up-and-down permanent magnets 21 and 31.
[0029] And in this example, justification of the permanent magnets 21 and 31 of these upper and lower sides is performed by the drive of the top vertical-drive equipment 22 by control of a controller 41, and bottom vertical-drive equipment 32. Moreover, this control by the controller 41 is performed based on plasma monitoring measurement of the plasma monitoring apparatus 42.
[0030] Next, one example about control of the plasma 44 by the controller 41 is explained using drawing 2 about a modification adjustment operation of the distribution condition of the plasma.
[0031] Drawing 2 is the diagram showing the relation of the concentration distribution and the amount of etching of the plasma here, and the diagram in which (a) shows plasma concentration distribution, and (b) are the diagrams showing the amount of etching. The location of a wafer is shown in an axis of abscissa among drawing 2 , and plasma concentration and thickness are shown in the axis of ordinate.
[0032] For example, it is assumed that the consistency became deep in the field corresponding to the center section of a wafer, and the consistency was thin in the field which counters the periphery as the distribution condition of the plasma 44 measured by the plasma monitoring apparatus 42 is shown in drawing 2 (a). In such a case, etching by sputtering becomes the inclination which advances early in the center section of a wafer 1, and advances late in the periphery as shown in drawing 2 (b).
[0033] Then, a controller 41 moves the up-and-down permanent magnets 21 and 31 in the direction approached mutually with the up-and-down vertical-drive equipments 22 and 32 based on the monitoring data about concentration distribution of the plasma from the plasma monitoring apparatus 42, respectively. ******* and the top permanent magnet 21 descend and the bottom permanent magnet 31 goes up.
[0034] If the up-and-down permanent magnets 21 and 31 are moved in the direction approached mutually, respectively, since the plasma 44 is lengthened outward [direction of path], the field where the plasma consistency of a center section is deep will be spread to the thin field of a periphery, consequently, on the whole, concentration distribution of the plasma 44 will be equalized by the up-and-down permanent magnet 21 and the variation rate of flux density distribution of 31. And if concentration distribution of the plasma 44 will be in a condition uniform on the whole, the advance of etching processing to the metal membrane 2 of the wafer 1 by sputtering will also be in a uniform condition over the whole.
[0035] Since modification adjustment of the distribution of plasma concentration can be suitably carried out [in / as mentioned above / this example] by carrying out modification adjustment of the location to the up-and-down permanent

magnet 21 and the electrodes 16 and 17 of the upper and lower sides of 31, The situation to which distribution of plasma concentration should have become an ununiformity from the condition of having been set up beforehand, by contamination of the processing room 11, modification of the ingredient of a wafer 1, etc. can be made to improve by moving the up-and-down permanent magnets 21 and 31.

[0036] And sputter etching processing to the metal membrane 2 of a wafer 1 can be advanced to homogeneity and stability over the whole by always maintaining concentration distribution of the plasma to homogeneity. Consequently, the product yield can be raised, while being able to change the etching processing to the metal membrane 2 of a wafer 1 into a uniform condition over the whole and being able to raise the quality and reliability of sputter etching processing.

[0037] In addition, it can carry out like the control about the homogeneity of the plasma concentration distribution which also mentioned above the control about the stability of the discharge condition of the plasma.

[0038] Moreover, although control to the plasma 44 by the permanent magnets 21 and 31 of the upper and lower sides through the controller 41 based on the monitoring data of the plasma monitoring apparatus 42 may be performed during the sputter etching processing to the wafer 1 of practical use, it is more desirable to perform periodically as correction of the plasma using a dummy wafer every two or more sheets. Furthermore, you may perform irregularly performing, when it falls rather than the set point to which the monitoring data of the plasma monitoring apparatus 42 were set beforehand etc.

[0039] According to said example explained above, the following effectiveness is acquired.

** since the homogeneity of plasma concentration and the stability of plasma discharge are controllable by carrying out modification adjustment of the location to the up-and-down permanent magnet 21 and the electrodes 16 and 17 of the upper and lower sides of 31 -- plasma concentration distribution -- always -- homogeneity -- moreover, stability can be made to always maintain plasma discharge

[0040] ** The product yield can be raised while being able to raise the quality and reliability of sputter etching processing, since sputter etching processing can be advanced to homogeneity and stability over the whole by maintaining plasma discharge to stability uniformly [distribution / plasma concentration].

[0041] ** Since control about the homogeneity of plasma concentration or the stability of plasma discharge can always be performed the optimal by performing justification of the up-and-down permanent magnets 21 and 31 by the controller 41 based on the monitoring data of the plasma monitoring apparatus 42, the product yield can be further raised to the quality-and-reliability list of sputter etching processing.

[0042] Drawing 3 is the transverse-plane sectional view showing the sputtering system which is the example 2 of this invention.

[0043] It is in the point constituted so that this driving gear 24 for top electrodes may be controlled by the controller 41 while the lifting and holding of the point that this example 2 differs from said example 1 are carried out instead of the up-and-down permanent magnets 21 and 31 being moved so that the top electrode 16 may move up and down with the rectilinear-motion driving gear 24.

[0044] In this example 2, the homogeneity of plasma concentration distribution and the stability of plasma discharge will be controlled by carrying out modification adjustment of the location to the permanent magnets 21 and 31 of the upper and lower sides of the top electrode 16 by the driving gear 24 for top electrodes by control of a controller 41. Therefore, according to this example 2, the same operation and effectiveness as said example 1 will be done so.

[0045] Drawing 4 is the transverse-plane sectional view showing the sputtering system which is the example 3 of this invention.

[0046] as for the point that this example 3 differs from said example 1, the up-and-down permanent magnets 21 and 31 are moved -- in addition, while lifting and holding are carried out so that the top electrode 16 may move up and down with the rectilinear-motion driving gear 24, it is in the point constituted so that this driving gear 24 for top electrodes may also be controlled by the controller 41.

[0047] In this example 3, it adds to modification adjustment of the location to the up-and-down permanent magnet 21 and the electrodes 16 and 17 of the upper and lower sides of 31 being carried out by the vertical-drive equipments 22 and 32 of the upper and lower sides by control of a controller 41. By carrying out modification adjustment also of the location to the permanent magnets 21 and 31 of the upper and lower sides of the top electrode 16 by the driving gear 24 for top electrodes by control of a controller 41, the homogeneity of plasma concentration distribution and the stability of plasma discharge will be controlled.

[0048] Therefore, according to this example 3, since the homogeneity of plasma concentration distribution and the stability of plasma discharge will be further controlled by the precision rather than said example 1, the effectiveness of said example 1 can be heightened further.

[0049] Drawing 5 is the transverse-plane sectional view showing the sputtering system which is the example 4 of this

invention.
[0050] The point that this example 4 differs from said example 1 is supported so that each division object may be moved within and without the direction of a path by each level driving gears 25 and 35, respectively, and is in the point constituted so that each of these level driving gears 25 and 35 may be controlled by the controller 41 while top permanent magnet 21A and bottom permanent magnet 31A are divided into the hoop direction instead of the up-and-down permanent magnets 21 and 31 being moved in the vertical direction.
[0051] In this example 4, the homogeneity of plasma concentration distribution and the stability of plasma discharge will be controlled by carrying out modification adjustment of the location of the direction of a path over the electrodes 16 and 17 of the upper and lower sides of the up-and-down permanent magnets 21A and 31A, respectively by the level driving gears 25 and 35 of the upper and lower sides by control of a controller 41.
[0052] Therefore, according to this example 4, the same operation and effectiveness as said example 1 will be done so.
[0053] Drawing 6 is the transverse-plane sectional view showing the sputtering system which is the example 5 of this invention.
[0054] The point that this example 5 differs from said example 1 is added to the up-and-down permanent magnets 21A and 31A being moved in the vertical direction by the up-and-down vertical-drive equipments 22 and 32. While top permanent magnet 21A and bottom permanent magnet 31A are divided into the hoop direction It is supported so that each division object may be moved within and without the direction of a path by each level driving gears 25 and 35, respectively, and it is in the point constituted so that each of these level driving gears 25 and 35 may be controlled by the controller 41.
[0055] In this example 5, it adds to modification adjustment of the location of the vertical direction over the electrodes 16 and 17 of the upper and lower sides of the up-and-down permanent magnets 21A and 31A being carried out, respectively by the vertical-drive equipments 22 and 32 of the upper and lower sides by control of a controller 41. By carrying out modification adjustment of the location of the direction of a path over the electrodes 16 and 17 of the upper and lower sides of the up-and-down permanent magnets 21A and 31A by the level driving gears 25 and 35 of the upper and lower sides by control of a controller 41 The homogeneity of plasma concentration distribution and the stability of plasma discharge will be controlled.
[0056] Therefore, according to this example 5, since the homogeneity of plasma concentration distribution and the stability of plasma discharge will be further controlled by the precision rather than said example 1, the effectiveness of said example 1 can be heightened further.
[0057] Although invention made by this invention person above was concretely explained based on the example, it cannot be overemphasized that it can change variously in the range which this invention is not limited to said example and does not deviate from the summary.
[0058] For example, as a plasma monitoring apparatus, it may not restrict using a plasma monitoring apparatus with a probe needle, but the plasma monitoring apparatus by laser induced fluorescence etc. may be used.
[0059] Moreover, as a magnet system, it may not restrict using a permanent magnet, but electromagnet equipment may be used.
[0060] As for the concrete configuration of the driving gear of the structure of a processing room, the maintenance structure of a wafer, a handling device, and a magnet system, selecting suitably according to processing conditions etc. is desirable.
[0061] Although the above explanation explained the case where invention mainly made by this invention person was applied to the sputter etching technique which is a field of the invention used as the background, it is not limited to it and can apply to the membrane formation processing by sputtering etc.
[0062]
[Effect of the Invention] It will be as follows if the effectiveness acquired by the typical thing among invention indicated in this application is explained briefly.
[0063] Since the homogeneity of plasma concentration and the stability of plasma discharge are controllable by carrying out modification adjustment of the location to the electrode of the upper and lower sides of an up-and-down permanent magnet, stable maintenance of the plasma discharge can always be carried out always uniformly [distribution / plasma concentration].
[0064] The product yield can be raised while being able to raise the quality and reliability of sputter etching processing, since sputter etching processing can be advanced to homogeneity and stability over the whole by maintaining plasma discharge to stability uniformly [distribution / plasma concentration].
[0065] Since control about the homogeneity of plasma concentration or the stability of plasma discharge can always be performed the optimal by performing justification of an up-and-down permanent magnet by the controller based on the

monitoring data of a plasma monitoring apparatus, the product yield can be further raised to the quality-and-reliability list of sputter etching processing.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the transverse-plane sectional view showing the sputtering system which is one example of this invention.
[Drawing 2] It is each diagram for explaining the operation, and the diagram in which (a) shows plasma concentration distribution, and (b) are the diagrams showing the amount of etching.
[Drawing 3] It is the transverse-plane sectional view showing the sputtering system which is the example 2 of this invention.
[Drawing 4] It is the transverse-plane sectional view showing the sputtering system which is the example 3 of this invention.
[Drawing 5] It is the transverse-plane sectional view showing the sputtering system which is the example 4 of this invention.
[Drawing 6] It is the transverse-plane sectional view showing the sputtering system which is the example 5 of this invention.
[Explanation of agreement]
1 -- A wafer (processed material), 2 -- A metal membrane, 10 -- Sputtering system, 11 [-- Wafer carrying-in taking out,] -- A processing room, 12 -- An exhaust port, 13 -- Gas supply opening, 14 15 [-- Power unit,] -- A vacuum pump, 16 -- A top electrode, 17 -- A bottom electrode, 18 19 -- Supporter material, 21 -- A top permanent magnet (magnet system), 22 -- Top vertical-drive equipment, 23 -- A push rod, 24 -- The vertical-drive equipment for top electrodes, 25 -- Bottom level driving gear, 31 [-- A bottom level driving gear, 41 / -- A controller, 42 / -- A plasma monitoring apparatus, 43 / -- A probe needle, 44 / -- Plasma.] -- A bottom permanent magnet (magnet system), 32 -- Bottom vertical-drive equipment, 33 -- A push rod, 35

[Translation done.]

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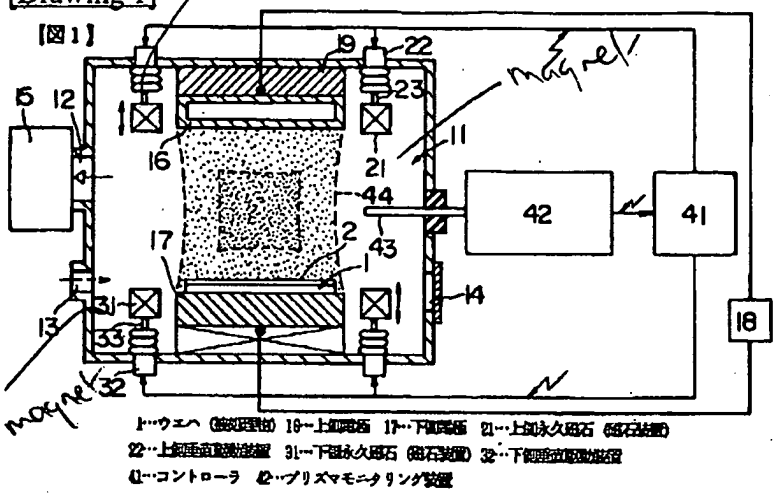
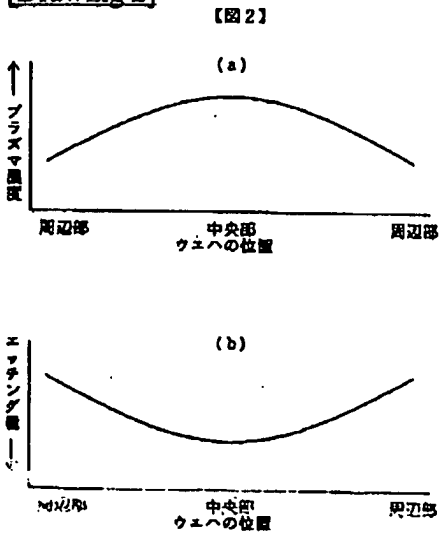
DRAWINGS

[Drawing 1]



[Drawing 2]



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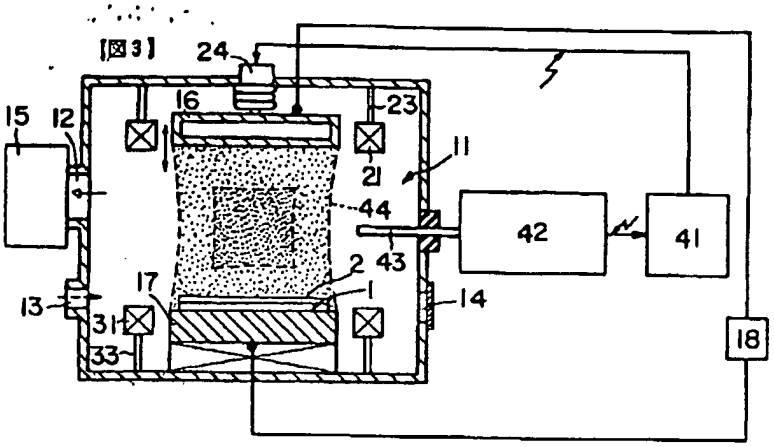

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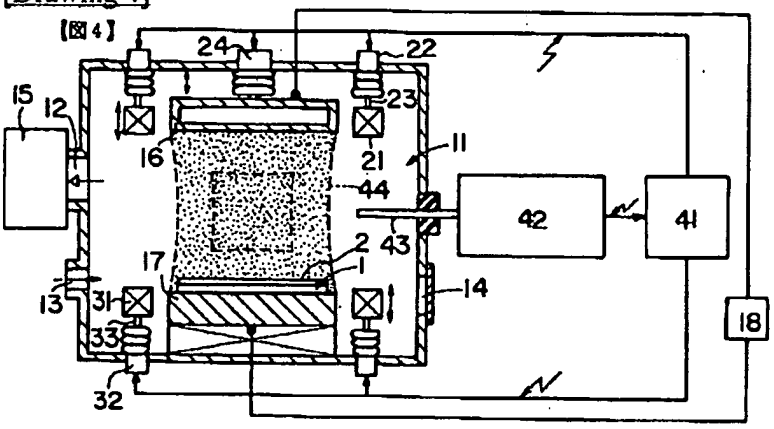

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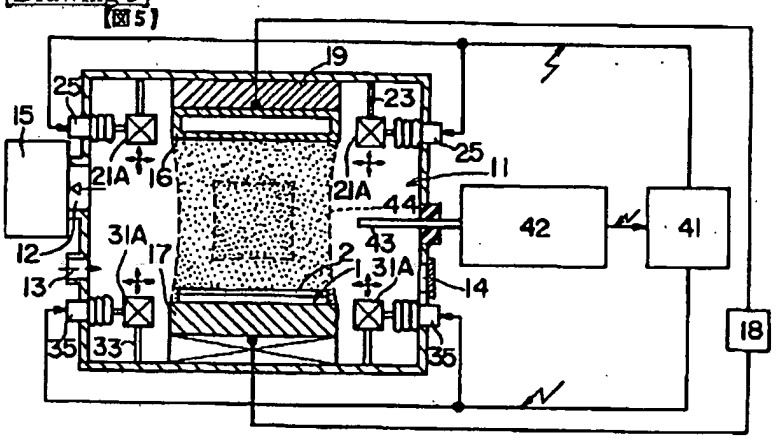
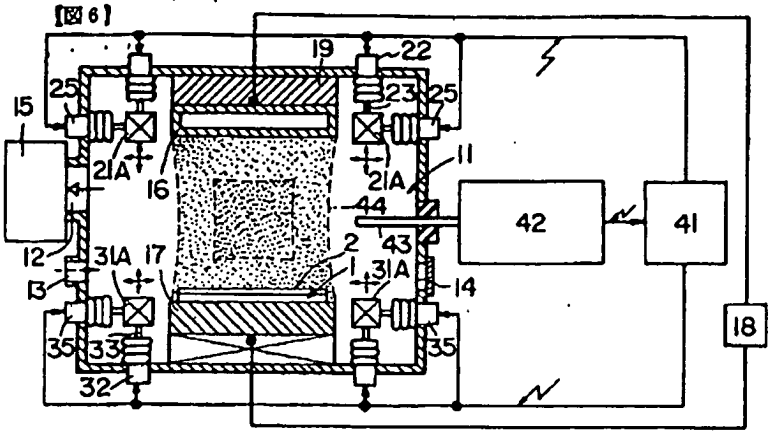


[Drawing 6]

[図6]



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